CALIFORNIA STATE DEPARTMENT OF PUBLIC HEALTH
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Weekly Bulletin

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*Carbon Monoxide Studies in the Industrial Hygiene Program**

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Industrial hygiene is that branch of public health work which has for its purpose the protection of health, the promotion of efficiency, and the prolongation of life of the industrial worker. In California, according to latest available census statistics, about 27 per cent of the gainfully employed workers, or 10 per cent of the total population, are employed in manufacturing and mechanical industries and in the extraction of minerals. In these industries there are known to be over 900 occupations involving contact with, or exposure to, materials such as gases, dusts, vapors, fumes, and chemicals, and to environmental conditions, such as excessive heat, dampness, noise, glare, and defective illumination, which may have a detrimental effect on the health of workers. One of the functions of the Industrial Hygiene Service of the State Department of Public Health, is to assist in the prevention and control of occupational diseases, by studying and evaluating these potential occupational health hazards, and by devising practical, effective methods for their control.

Carbon monoxide gas is one of the most widespread and treacherous poisons connected with human life and activities. It is colorless, odorless, tasteless, and nonirritating, and seldom gives warning of its presence. It is produced by the incomplete combustion of carbon-containing materials. The burning of fuels such as wood, coal, charcoal, gas, oil, kerosene, and gasoline is a source of danger to health, unless an efficient method of removing the products of combustion is provided.

Many persons are killed in their homes by breathing carbon monoxide escaping from heating stoves which are improperly adjusted or inadequately vented. When a gas flame touches cold metal, carbon monoxide is generated. Therefore, the unvented instantaneous hot water heater is a constant menace to health. Automobiles and other motor vehicles are very efficient generators of this deadly gas. The average gasoline engine gives off one cubic foot of carbon monoxide per minute for every twenty horsepower. An automobile engine idling in a small, closed garage, will contaminate the air to the danger point in about three minutes.

Human experience with the poisonous effects of carbon monoxide probably began during prehistoric ages when man first came into possession of fire. References to this poison in ancient literature indicate that it was a frequent cause of death by accident, by suicide, and by use as an instrument of punishment and torture. During the Middle Ages, women were accused of witchcraft and burned at the stake,

* Paper to be presented at meeting of Health Officers' Section, League of California Municipalities, Santa Barbara, September 8, 1938.

for "hexing" persons found dead as a result of inhaling this gas in tightly closed dwellings, where fires were kept burning.

With the increase in the use of coal, carbon monoxide poisoning became more common, due to the use of improperly constructed fireplaces and ovens, where the coal was incompletely burned, and also due to the generation of this gas in coal mines, where it is commonly known as "white damp," by explosions, mine fires, and the use of powder for blasting. In the fifteenth century, Paracelsus and Agricola attributed the sudden death of miners underground, from no apparent cause, to evil spirits, and recommended prayer and fasting as preventive measures.

Each development of a new method of producing heat for home and industrial consumption has multiplied the opportunities for accidental poisoning, until today, with the additional hazard due to the general use of gas burning appliances, carbon monoxide has become one of the most widely distributed and most frequent causes of accidents.

In industry carbon monoxide may be found wherever heat or power are obtained by the combustion of organic substances. There is hardly any type of industrial activity in which this gas is not encountered to some extent. Moreover, the carbon monoxide hazard is definitely increasing in the industrial world. For example, in the steel industry, the demand for new grades and qualities of steel has resulted in the use of specially designed gas furnaces. Improvements in the construction of these furnaces have reduced the carbon monoxide hazard per unit of equipment, but opportunities for exposure to this gas are greater, due to the steady increase in the total number of units in operation.

In the gas industry, workers employed in the manufacture of gas, as well as those who test and repair meters, underground pipe lines and gas mains, are frequently exposed to dangerous amounts of carbon monoxide. Workers using gas-heated appliances are often exposed to carbon monoxide gas due to direct gas leakage through loose connections or defective tubing, or as a result of incomplete combustion of the fuel gas. Such appliances include hand irons and ironing machines used in steam laundries, hat presses, soldering stoves, lead pots, steam boilers, gas ovens, and gas-heated furnaces.

Other common sources of carbon monoxide poisoning in industry include the exhaust gas from automobiles, trucks, and buses in garages, service stations, repair shops, and on the highways; the exhaust gas from internal combustion engines wherever they are used; in battleships, in the turrets during gun firing, and in the furnace rooms, where the effects of carbon monoxide are often attributed to heat prostration; the use of acetylene gas in welding; celluloid manufacture, during ignition and detonation; the distillation of coal tar; the melting and pouring of metal in iron and brass foundries; in the iron and steel industry, from leaky blast furnaces, gas valves and mains, and when cleaning out furnaces; in mines during fires, explosions of gas or coal dust, and in blasting operations; in the printing industry, from type melting kettles and lead pots; in unvented blacksmith's forges; in the smelting process in soda manufacture; and in the textile industry in ring spinning, carding, and other processes where heat is required.

The exhaust gas from gasoline engines contains an average of 7 per cent carbon monoxide; gas from blast furnaces in steel mills, 28 per cent; from Bessemer furnaces, 25 per cent; manufactured illuminating and fuel gas, 25 per cent to 30 per cent; products of combustion of 40 per cent nitroglycerin dynamite used in blasting, 28 per cent.

Although carbon monoxide causes more deaths than all other gases combined, it is not a true poison in the sense that it destroys tissues directly. It is physiologically inert except for its ability to deprive the tissues of oxygen. This asphyxiating effect is brought about by the combination of carbon monoxide with haemoglobin, the oxygen-carrying element of the blood, forming a relatively stable compound, and rendering the haemoglobin incapable of carrying oxygen from the lungs, to the tissues and organs of the body. Haemoglobin has nearly 300 times as great an affinity for carbon monoxide as it has for oxygen.

The time necessary for a given amount of haemoglobin to combine with carbon monoxide decreases rapidly with increasing concentrations of the gas in the air breathed. A few breaths of air containing as much as 1 per cent of carbon monoxide may produce a fatal blood saturation of 60 per cent to 80 per cent. The rate of absorption of carbon monoxide by the blood increases with physical exertion, due to increase in rate and depth of breathing, and hence greater air intake. Long exposure to low concentrations of the gas causes more serious and lasting effects than short exposure to higher concentrations, due to the longer time the body tissues are deprived of oxygen.

Persons with physical defects such as bronchitis, asthma, alcoholism, obesity, or chronic heart or vascular disease, are particularly susceptible to the effects of carbon monoxide. There is no apparent variation in susceptibility due to sex.

When two individuals, one of whom is larger than

the other, or when an adult and a child, both at rest, breathe air containing carbon monoxide, the smaller individual absorbs the gas more rapidly than the larger, and tend to develop symptoms sooner, due to more active metabolism and greater volume of respiration in proportion to volume of blood in the body. A man at rest uses little more than one-third of the oxygen carried to his tissues by the blood. During muscular exertion, nearly two-thirds is utilized. Therefore, the blood of a resting man may become nearly one-third saturated with carbon monoxide without causing serious symptoms, while if he puts forth any considerable muscular effort, the fraction of his haemoglobin remaining free from carbon monoxide is insufficient to transport the oxygen needed, and he may collapse. After mine explosions, men making vigorous efforts to escape have collapsed and died as the result of carbon monoxide asphyxiation, while other miners, breathing the same air, but waiting quietly until help arrived, have recovered without any serious after-effects.

The pathological changes brought about by carbon monoxide inhalation, are due to oxygen starvation of the tissues. If this is prolonged, there will be in some cases, permanent damage to certain organs of the body, particularly the nervous system. Many fatal cases of carbon monoxide asphyxiation show an extensive pneumonia, or focal softening of the brain. In other cases, no gross tissue damage can be found after death.

The symptoms of carbon monoxide asphyxiation may be divided into two stages. In the first stage, the victim may experience a sensation of tightness across the forehead, dilatation of cutaneous blood vessels, headache, throbbing in the temples, weariness, weakness, dizziness, nausea, and vomiting; loss of strength and muscular control; increased pulse and respiration; and finally collapse and loss of consciousness. When the concentration of carbon monoxide in the air breathed is high, or when the victim is at rest, loss of consciousness may result without any of these warning symptoms. In the second stage, the blood pressure falls, muscular control is lost, reflexes are dulled, and finally abolished; intermittent convulsions may occur; breathing becomes slow and shallow, and finally ceases, if exposure to the gas is continued. Judgment is sometimes impaired to the extent that the victim of carbon monoxide fights with his rescuers when they attempt to remove him from the presence of the gas to fresh air. He may grow not only indifferent to the danger, but even be soothed to drowsiness, a condition resembling alcoholic intoxication.

The accompanying chart (Figure 1) illustrates graphically the relation between the amount of carbon monoxide in the air breathed, the duration of exposure, the blood haemoglobin saturation, and the physiological effects produced.

Workers constantly exposed to carbon monoxide gas in garages, for example, or in industries where gas-heated appliances are used, are rarely exposed to amounts sufficient to cause acute poisoning, but breathe small amounts of the gas day after day and year after year. Some of these workers complain of insomnia, others of gastro-intestinal disturbances, particularly nausea, and loss of appetite; while others suffer from shortness of breath on exertion, general lassitude and fatigue, and a secondary anemia. The principal single cause of lost time in these industries is the typical carbon monoxide headache, with which every worker who is exposed to this gas is familiar. It is an intense throbbing frontal or basal headache, which is increased on bending, and may be associated with dizziness and nausea.

The after-effects of carbon monoxide inhalation may include headaches, muscular pains, long periods of unconsciousness, loss of strength, disturbances of speech and hearing, paralysis, temporary blindness, extreme nervousness, tremors, and mental and emotional disturbances. These effects are usually temporary, but may be more or less permanent, depending upon duration of oxygen starvation, personal susceptibility, and physical condition before exposure. Preexisting organic disease, such as myocarditis, may be aggravated, with permanent impairment of normal function.

The diagnosis of carbon monoxide asphyxiation depends upon the history of exposure, the appearance of the victim, the symptoms of oxygen starvation, and most important, upon the detection of carbon monoxode haemoglobin in the victim's blood. For this purpose we have found the portable pyrotannic acid apparatus to be particularly convenient. By means of this instrument, the percentage of blood saturation with carbon monoxide, can be determined in a few minutes by testing a drop of blood obtained from a small puncture wound in the finger, and a positive diagnosis made on the spot.

(Continued in next issue)

DISTRIBUTION OF DRUGS

Large quantities of drugs for the treatment of syphilis, for use in individuals who are unable to pay for such products, have been distributed to private physicians, health officers, and clinics. A total of more than 35,000 ampules of such products was sent out from the bureau during June.

MORBIDITY

Complete Reports for Following Diseases for Week Ending August 6, 1938

Chickenpox

71 cases: Alameda 1, Albany 2, Berkeley 8, Hayward 1, Oakland 2, El Dorado County 1, Fresno County 1, Fresno 1, Los Angeles County 6, Burbank 1, El Monte 1, Glendale 1, Huntington Park 1, Los Angeles 13, Santa Monica 3, Whittier 1, South Gate 3, Maywood 1, Salinas 1, Sacramento 3, Chula Vista 1, San Diego 3, San Francisco 7, Paso Robles 1, Santa Barbara County 1, Santa Barbara 2, Santa Maria 1, San Jose 1, Ventura 1, Alhambra 1.

Diphtheria

17 cases: Oakland 1, Calaveras County 1, Los Angeles County 2, Los Angeles 8, San Diego 3, San Jose 1, Marysville 1.

German Measles

12 cases: Alameda County 1, Berkeley 2, Oakland 1, Los Angeles County 1, Claremont 1, Los Angeles 1, Huntington Beach 1, Santa Ana 1, San Bernardino County 1, San Francisco 1, San Joaquin County 1.

Influenza

10 cases: Los Angeles County 2, Glendale 1, Los Angeles 5, Pasadena 1, San Joaquin County 1.

Malaria

18 cases: Los Angeles 1, San Francisco 1, Sonoma County 1, Winters 13, Yuba County 1, Marysville 1.

Measles

190 cases: Alameda County 1, Berkeley 5, Oakland 18, El Cerrito 1, Fresno County 2, Kern County 2, Bakersfield 1, Hanford 2, Los Angeles County 22, Alhambra 1, Arcadia 2, Burbank 1, Culver City 2, Long Beach 5, Los Angeles 16, Manhattan Beach 1, Monrovia 3, Pasadena 4, Redondo Beach 1, Santa Monica 1, Whittier 1, Monterey Park 1, Maywood 1, Carmel 1, Orange County 1, Brea 1, Fullerton 1, Orange 1, Santa Ana 4, Laguna Beach 1, Sacramento 9, San Bernardino County 11, Redlands 1, San Bernardino 1, San Diego County 6, Escondido 1, National City 1, Oceanside 3, San Diego 26, San Francisco 3, Paso Robles 2, San Luis Obispo 1, Santa Barbara County 2, Santa Barbara 1, San Jose 5, Sonoma County 1, Stanislaus County 1, Ventura County 5, Fillmore 1, Oxnard 1, Ventura 3, Woodland 1.

Mumps

128 cases: Alameda County 1, Alameda 3, Berkeley 7, Livermore 1, Oakland 16, San Leandro 1, Contra Costa County 3, Fresno County 1, Fresno 1, Kern County 1, Los Angeles County 4, Culver City 1, Glendale 4, Long Beach 2, Los Angeles 17, Monrovia 1, Pomona 1, Santa Monica 5, South Pasadena 1, Lynwood 1, Signal Hill 1, San Anselmo 5, Fairfax 1, Salinas 1, Sacramento 13, San Bernardino County 2, San Diego County 3, La Mesa 5, San Diego 8, San Francisco 8, Stockton 4, San Mateo County 1, Santa Barbara County 1, Santa Clara County 1, San Jose 1, Siskiyou County 1.

Pneumonia (Lobar)

29 cases: Oakland 1, Crescent City 1, Kern County 1, Tehachapi 1, Los Angeles County 5, Los Angeles 7, St. Helena 1, Sacramento County 1, Sacramento 1, San Diego 2, San Francisco 2, Stockton 2, Santa Barbara 2, Solano County 1, Stanislaus County 1.

Scarlet Fever

49 cases: Alameda 1, Oakland 1, Contra Costa County 2, Fresno County 1, Fresno 1, Kern County 2, Los Angeles County 10, Avalon 1, Glendale 1, Los Angeles 12, Santa Monica 1, Torrance 2, Lynwood 1, Merced 1, Fullerton 1, Newport Beach 1, Santa Ana 2, San Bernardino County 2, San Bernardino 1, San Diego 3, Watsonville 1, Santa Paula 1.

Smallpox

25 cases: Contra Costa County 1, Concord 3, Kern County 1, Los Angeles County 6, Los Angeles 6, Sacramento County 1, San Joaquin County 6, Visalia 1.

Typhoid Fever

12 cases: Fresno County 1, Imperial County 1, Calexico 1, San Rafael 2, Stockton 1, Santa Barbara County 1, San Jose 1, Tulare County 1, California 3.*

Whooping Cough

191 cases: Alameda County 4, Berkeley 6, Oakland 11, San Leandro 1, El Dorado County 1, Inyo County 1, Los Angeles County 16, Alhambra 1, Arcadia 1, Culver City 2, Los Angeles 46, Pasadena 3, Pomona 3, San Fernando 1, San Gabriel 8, Santa Monica 3, South Gate 5, San Anselmo 8, Mono County 1, Salinas 2, St. Helena 1, Nevada County 5, Orange County 4, Santa Ana 1, Laguna Beach 1, Sacramento 6, San Bernardino County 1, San Bernardino 1, San Diego County 2, Escondido 2, San Diego 8, San Francisco 15, San Joaquin County 2, Stockton 1, Atherton 1, Menlo Park 2, Santa Barbara 5, San Jose 3, Sonoma County 1, Stanislaus County 1, Ventura County 1, Santa Paula 1, Woodland 1, Monterey County 1.

Meningitis (Epidemic)

One case: Imperial County.

Dysentery (Amoebic)

One Case: Fullerton.

Dysentery (Bacillary)

11 cases: Oakland 1, Los Angeles County 4, Los Angeles 2, San Francisco 3, Sonoma County 1.

Pellagra

One case: Riverside County.

Poliomyelitis

One case: Shasta county.

Tetanus

4 cases: Los Angeles County 1, Los Angeles 2, Lynwood 1.

Trachoma

4 cases: Contra Costa County 1, Fresno County 1, Riverside County 1, San Francisco 1.

Encephalitis (Epidemic)

One case: Sacramento.

Food Poisoning

16 cases: Reedley 1, Placer County 14, San Francisco 1.

Undulant Fever

8 cases: Los Angeles 1, Pasadena 1, Santa Ana 1, Sacramento 1, San Bernardino County 1, Santa Barbara 2, Sonoma County 1.

Coccidioidal Granuloma

3 cases: Monrovia 1, Fullerton 1, Los Gatos 1.

Septic Sore Throat

2 cases: Riverside County 1, Sonoma County 1.

Relapsing Fever

One case: San Bernardino County

Rabies (Animal)

17 cases: Bakersfield 1, Los Angeles 1, Long Beach 1, Los Angeles 10, Hawthorne 1, Monterey County 1, San Joaquin County 2.

FOOD PRODUCTS DESTROYED

More than 100,000 pounds of beans and 250,000 pounds of prunes were destroyed by the Bureau of Food and Drugs during the month of June, because of fire damage. Among other products destroyed because of unfitness for human consumption were whiskey, wine, eggs and egg products, canned crab, and dried figs.

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* Cases charged to "California" represent patients ill before entering the state or those who contracted their illness traveling about the state throughout the incubation period of the disease. These cases are not chargeable to any one locality.

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